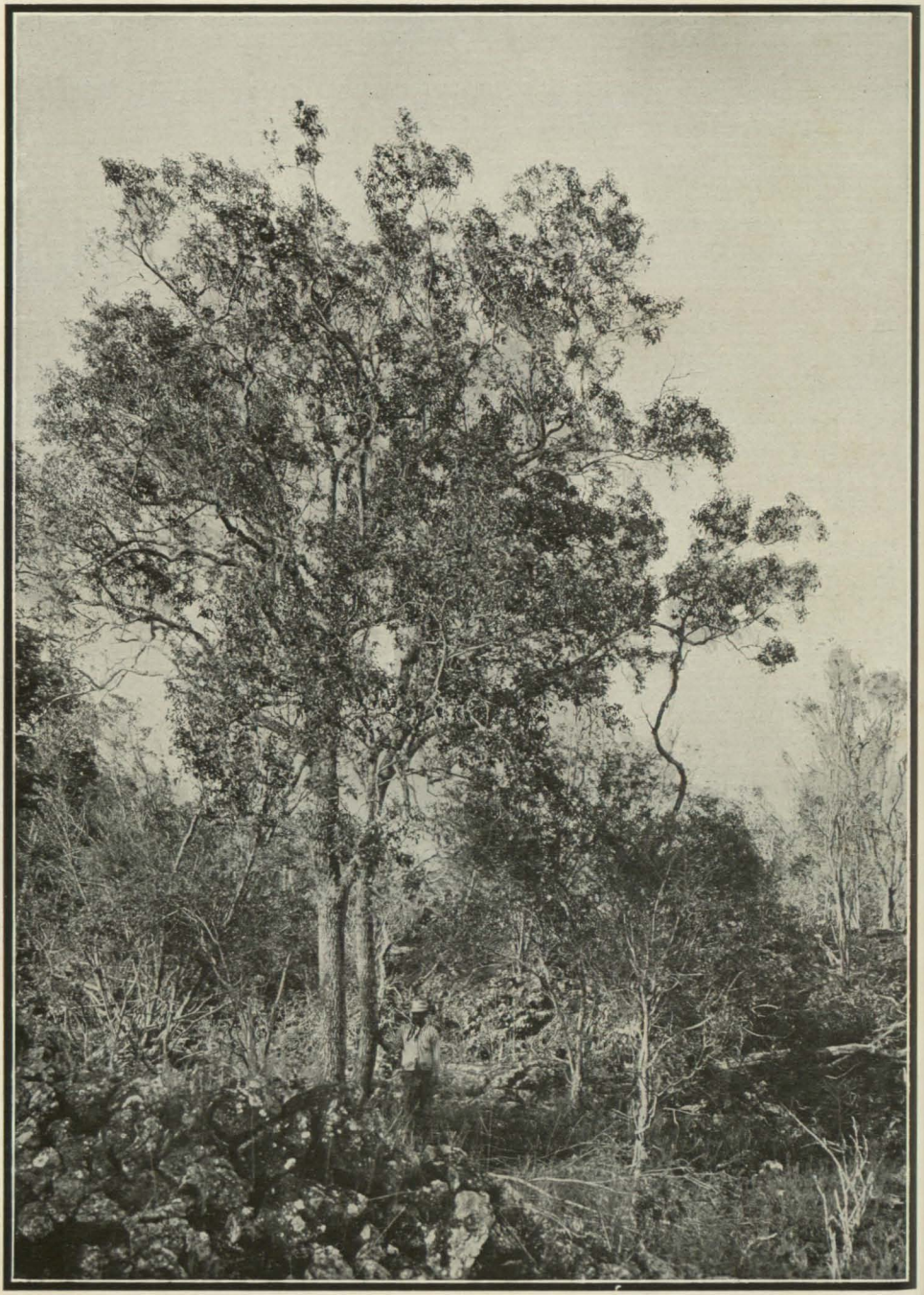


Santalum Pilgeri var. **luteum** Rock, growing on the lava-fields of Puuwaawaa, North Kona, Hawaii, elev. 2700 feet.

BOTANICAL BULLETIN No. 3. DECEMBER, 1916

Territory of Hawaii
BOARD OF AGRICULTURE AND FORESTRY

DIVISION OF FORESTRY
C. S. JUDD, *Superintendent*

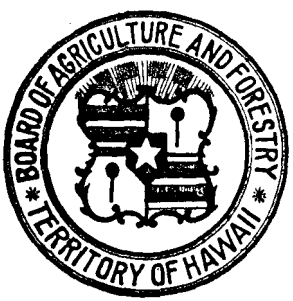
The Sandalwoods of Hawaii

A REVISION OF THE HAWAIIAN SPECIES OF THE GENUS SANTALUM

BY

JOSEPH F. ROCK
Consulting Botanist

Issued December 28, 1916



HONOLULU, T. H., 1916

LETTER OF TRANSMITTAL

HONOLULU, HAWAII, October 1, 1916.

Board of Commissioners of Agriculture and Forestry,
Honolulu, Hawaii.

GENTLEMEN:

I have the honor to transmit herewith the manuscript of a paper entitled "The Sandalwoods of Hawaii," which is a revision of the Hawaiian species of the genus Santalum by Mr. Joseph F. Rock, *Consulting Botanist of the Division of Forestry, and Botanist of the College of Hawaii,* and to recommend that it be published as Botanical Bulletin No. 3 of the Division of Forestry.

This paper is the result of careful research on the part of Mr. Rock, who has straightened out the confusion which existed in regard to the proper botanical classification of the Hawaiian sandalwoods, and will no doubt be of interest to those in these Islands who are not acquainted with the nine species and two varieties of sandalwood.

Very respectfully,

C. S. JUDD,
Superintendent of Forestry.

Approved:

Board of Commissioners of Agriculture and Forestry,
October 5, 1916.

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ILLUSTRATIONS

HISTORY OF THE SANDALWOOD TRADE IN THE HAWAIIAN ISLANDS.

Up to the middle of the eighteenth century sandalwood was exclusively obtained from the East Indies, furnished by *Santalum album*. But after Captain Cook and his successors made Europeans familiar with the geology of the South Seas, enterprising traders went in search of the wood among the innumerable islands which dot the broad Pacific. The first group visited from Manila was Viti or Fiji. The sandalwood of that group, confined to the Island of Vanua Levu and derived from *Santalum Yasi*, a middle-sized tree, had long been famous in those waters and induced Tongans to undertake regular trading expeditions to the place where it grew, and they even attempted to transplant the tree to Tonga. So great was the demand for the wood, both in Polynesian and Chinese markets, that, about 1816, there was scarcely enough left for home-consumption and in 1840 the U. S. Exploring Expedition had difficulty in obtaining a few herbarium specimens.

About 1778 the attention of the commercial world was first directed to the existence of sandalwood in these Islands. A Captain Kendrick of a Boston brig is known to have been the first who left two men on Kauai to contract for several cargoes. The natives term the wood *Laau ala* meaning "fragrant wood," while they call the tree *Iliahi;* the species (*S. littorale*) growing near the sea they call *Iliahi aloe.*

Mention is made of the magnificent groves that formerly covered parts of these islands, especially the stony, and well drained places, where now only single individuals may be found, save on Hawaii, in the district of South Kona, where small groves still exist, but already in a dying condition.

The infant kingdom of Hawaii, under the government of the first Kamehameha, exported vast quantities of the wood. The sandalwood was to these Islanders the start in life, and it is doubtful if Kamehameha would have succeeded so well, had it not been for the profitable trade in sandalwood which he carried on with outsiders.

From 1790 to 1820 numerous vessels called for sandalwood, bringing all sorts of things in exchange, and about 1818 Kamehameha and his people began to accumulate considerable wealth. In one year alone 400,000 dollars were realized. Kamehameha

hearing of the great profits derived from sales in China determined to send a ship of his own to Canton laden with the produce. Extravagant port charges and misconduct of the English captain, etc., led to the commercial failure of this enterprise, and the king found himself 3,000 dollars out of pocket.

Under the reign of his successor (Liholiho), the sandalwood began to be exhausted, though in 1820, the records show that 80,000 dollars worth of the wood had been paid for the barge "Cleopatra"* and in 1822 we hear of a voyage to Kauai to collect the annual tribute of the wood in that Island.

But the product became every day more difficult to procure and could no longer be demanded in payment of taxes. However, quantities of the wood were now and then brought together, but they were quite insufficient to fill whole vessels as in times gone by.

Another very fragrant wood was discovered about that time, the *Naio* of the natives, *Myoporum sandwicense* A. Gray, belonging to an entirely different family. It was used as a substitute but could not revive the trade.

In November, 1829, a vessel arrived at these Islands from which it was learned that an island in the south Pacific had been discovered which harbored quantities of the much sought for sandalwood.

Boki, the Governor of Oahu, was made acquainted with the situation and he, full of enthusiasm and delighted with a chance of retrieving his ruined credit, accepted the proposition to fit out an expedition for taking permanent possession of it. Two men-of-war-brigs, the "Kamehameha" and the "Becket" were selected for the purpose, and after having been well provided with ammunition, arms, and stores for colonization, the expedition started on its eventful voyage. Nearly 500 people, including ten foreigners, embarked in these two vessels, all intent on making a fortune. The boats stopped first at Rotuma,* north of Fiji, and there discontent began to show itself due to the hardships of the voyage.

The destination turned out to be the Island of Eromanga,* and the "Kamehameha" having completed her preparation, started ten days in advance of her consort, but she was never heard of

*If a vessel was to be bought, the chief agreed to give an amount of sandalwood, in exchange, equal to the bulk of the craft; taking her greatest length, depth, and breadth, a pit of the same extent was dug, making no allowance for bilge, which was filled with sandalwood, and this amount exchanged for the desired object.

*Rotuma, Rotuam or Grenville Island, discovered by Capt. Edwards in 1791; 8 miles E-W, 2 miles N-S. 800 feet high.

*Eromanga is a high and rocky island of the New Hebrides, 30 miles by 32 miles.

again. The "Becket" reached Eromanga in safety and remained there some weeks, committed outrages on the natives, which led to hostilities which completely frustrated the object of the expedition. The "Kamehameha" not arriving, and a distemper breaking out, which carried off many of the company, including the commanding chief, the "Becket" resolved to return home.

A scene of horror now ensued which baffles description; crowded with the sick and dying and the dead, the vessel, slowly making her way through the sultry regions of the tropics, became a floating morgue. The sufferings of the survivors were aggravated by the want of water, food and medicines. Out of two hundred and twenty-six souls that comprised her company on leaving Rotuma, only twenty, eight of whom were white men, returned home. When she arrived at Oahu, on the 3rd of August, 1830, weeping and wailing could be heard night and day. The loss of so many active and fine men was felt as a national calamity and formed a sad conclusion of the sandalwood trade of these Islands.

THE HAWAIIAN SPECIES OF THE GENUS SANTALUM.

The genus *Santalum* is represented in the Hawaiian Islands by nine species and two varieties.

According to the old arrangement, as carried out by Hillebrand and other writers, the Islands were accredited with three species—*S. Freycinetianum, S. Pyrularium, S. Haleakalae,* and four varieties belonging to *S. Freycinetianum.* This erroneous classification followed by several authors, such as Gray, Hillebrand, Mann and the writer, was due to Gaudichaud's badly figured type of *S. Freycinetianum* in the Atlas of Bot. Voyage Uranie. The plate in that Atlas does not at all agree with the typical specimen of *S. Freycinetianum* collected by Gaudichaud on the Island of Oahu in 1827, which the writer had occasion to examine while working in the herbaria in Europe.

The Hawaii species of Santalum with obconical perigonal tubes were taken for the typical *S. Freycinetianum,* while the true *S. Freycinetianum* of Gaudichaud from the eastern division of Oahu was referred at least by Hillebrand and the writer to *S. ellipticum.*

Santalum Freycinetianum has not an obconical perigonal tube but a campanulate one, and belongs therefore to the group with *S. ellipticum, S. pyrularium, S. Lanaiense* and *S. Haleakalae.* Of the four former varieties of *S. Freycinetianum,* three—*paniculatum, cuneatum* and *littorale,* which have all obconical, yellowish perigones — have been raised to specific rank in the group of which *S. Pilgeri,* a distinct and new species, with an obconical perigonal tube, is the type. This latter species was referred to *S. Freycinetianum,* erroneously by various authors, but differs considerably from it. No doubt all these species have probably originated from two species which have been selected as the types of these two naturally defined groups; of the first group *S. pyrularium* may be the ancestor of the other species in that group, while *S. Pilgeri* may be the ancestor of the species of the second group. They are certainly closely related.

The genus is represented on all the islands of the group and ranges as far northwest as Laysan Island, which possesses a variety of *S. cuneatum* (var. *laysanicum*). The species *cuneatum* occurs only in the very dry and arid regions of Lanai

and on the lava flows of East Maui; it is therefore not surprising to find a variety of it on the barren island of Laysan. Nearly all of the Hawaiian sandalwoods prefer the drier regions, especially open rocky situations, from near sea level to over 5,000 feet elevation. On Hawaii they occur exclusively on lava flows, ranging from 2,500 to 5,000 feet in altitude, and curiously enough mainly on *aa* (rough) lava and rarely on *pahoehoe* (smooth) lava.

Santalum Pilgeri, probably the tallest and largest species, inhabits the *aa* flows on the southern slopes of Mauna Loa at an elevation of 5,000 feet near Pulehua, and forms almost a pure stand, but occurs also scattered in the forest bordering the big central plain, in company with *Acacia Koa, Myoporum sandwicense* and *Sophora chrysophylla.* This is the largest grove now extant.

Everywhere else in the group the various species of sandalwood occur only scattered here and there, as individuals.

Santalum littorale is still quite common in small gulches below the lighthouse on the slopes of Diamond Head on Oahu, where it is a small shrub several feet in height. The typical *S. Freycinetianum,* the first species described from these Islands in 1830 by Gaudichaud, is still quite abundant on the lower and middle slopes in Palolo Valley, but since the planting of pineapples on some of the lower ridges, it, as well as many good *koa* trees which were perhaps coincidentally its host, had to make way for the pineapples.

On Kauai sandalwood is very scarce and is found only in the outskirts of the forests, especially at Halemanu and Kaholuamano, at an elevation of from 3,000 to 3,500 feet. One species *S. pyrularium* is peculiar to Kauai, while *S. ellipticum* occurs on Kauai (eastern division) and also on the western range of Oahu.

Santalum Haleakalae, as the name implies, is peculiar to Haleakala on Maui, where it grows on old lava flows at an elevation of from 7,000 to 9,000 feet; the writer found it, however, considerably lower on the same mountain, but on the southern slopes.

S. paniculatum inhabits the open rocky situations near the Volcano of Kilauea, on cliffs and in deep lava cracks, and fissures caused by earthquakes, as well as on the lava plains toward Mauna Loa, but there always as a tree.

Sandalwood must certainly have formed a large percentage of the tree growth in the drier regions or mixed forests, in

the early days, before the value of the wood became known to the natives of these Islands. It must have existed in pure stands, or as forests, or it would have been next to impossible to export as much as $400,000 worth per annum.

Sandalwood is a hemiparasite; that is, it absorbs its nutriment not entirely from the ground but also from the roots of other trees (hosts) by means of *haustoria,* or suck organs, which are very numerous on the roots of sandalwood trees and which they sink into the roots of their hosts.

It is, however, not a parasite like the mistletoe, which is entirely dependent on its host for food, but can grow quite independently and even in pure stands as can still be observed on the lava fields of Kona, Hawaii.

The writer observed also *S. cuneatum* growing all alone with no trees or other plants near it within a radius of a mile, on the eastern end of Lanai. This proves conclusively that it is not always dependent on other trees for food.

The Oil of **Santalum Freycinetianum** Gaud.

By ALICE A. BALL,

Instructor in Chemistry, College of Hawaii.

A representative portion of the log of *Santalum Freycinetianum* was rasped as finely as possible and the resulting product steam distilled. The distillate was extracted with ether to remove the oil. The ethereal solution was dried with anhydrous sodium sulphate and the ether removed by distillation. The resulting oil amounting to .75-1% of the weight of the wood taken, was a clear yellow, somewhat thick liquid of a characteristic aromatic odor, but much milder and less pungent than the sandalwood oil of commerce. The specific gravity at 25° C. compared with water at 4° C. was .97. The refractive index at 26° C. was 1.5040. The oil was assayed for santalol according to the method outlined in the U. S. Pharmacopeia VIII, and the percentage of santalol found to be 96-97%. The acetylated oil gave a refractive index of 1.4890 at 26° C.

From the above data it is readily seen that the oil of this species of sandalwood compares favorably with the better grade of oil of *Santalum album,* which assays from 90-98% santalol. The oil of *Santalum Freycinetianum* meets the requirements of sandalwood oil according to the U. S. Pharmacopeia VIII.

The above analysis was made at the Chemical Laboratory of the College of Hawaii.

SYSTEMATIC PART

Key to the Hawaiian Species of Santalum.

Perigonal tube campanulate to cylindrical:
- Drupe ovate, smooth:
  - Inflorescence terminal:
    - A raceme or panicle, flowers many:
      - Leaves ovate-oblong, on petioles of 1-2 cm..... **S. Freycinetianum**
    - A bracteate corymb:
      - Leaves obovate-oblong ..... **S. Haleakalae**
  - Inflorescence axillary:
    - Flowers large and few:
      - Leaves large, orbicular ..... **S. Lanaiense**
    - Flowers loose, few, paniculate:
      - Leaves elliptical-oblong ..... **S. ellipticum**
- Drupe obovate, large, rough ..... **S. pyrularium**

Perigonal tube obconical:
- Drupe ovoid:
  - Inflorescence a short axillary raceme, flowers in clusters of 3-6, orange yellow:
    - Leaves ovate to obovate, large, dark green ..... **S. Pilgeri**
  - Inflorescence a large, terminal, densely flowered panicle:
    - Leaves chartaceous, large, ovate to suborbicular, glaucous ..... **S. paniculatum**
- Drupe globose to subglobose:
  - Inflorescence a short panicle in the axils of the leaves:
    - Leaves thick, coriaceous, orbicular to suborbicular, with truncate to cuneate base ..... **S. cuneatum**
  - Inflorescence terminal and axillary, flowers small, fragrant:
    - Leaves small, ovate-elliptical, glaucous ..... **S. littorale**

Santalum Freycinetianum Gaud. (Typical specimen from Palolo Valley, Oahu.)

Santalum Freycinetianum Gaud. Bot. Voy. Uranie, 442, t. 45, 1830.

Santalum Freycinetianum Gaud. δ var. *ellipticum* Hbd. Fl. Haw. Isl. 390, 1888, in part.

Santalum ellipticum Rock (not Gaud.) Indig. Trees Haw. Isl. 131, 1913.

A small tree with slender, drooping branches, glabrous throughout; leaves ovate-oblong, acute, tapering at both ends, thin, chartaceous, glossy above, dull underneath, dark green, with reddish tinge, 5-7 cm. long, 1.5-2 cm. wide, on slender reddish petioles of 1-2 cm.; inflorescence a simple terminal raceme 5-7 cm. long, flowers opposite or in clusters of 3-6, rarely more, on pedicels of 3 mm., or occasionally subsessile; perigone reddish as is the whole inflorescense, 4-6 mm. long, campanulate, the acute, ovate lobes as long as the tube; disk-lobes short and broad; anthers slightly longer than the filaments, tufts of hair as long as the stamen or slightly shorter; style nearly as long as the perigone, slender, with 3 capitellate lobes; drupe ovoid, 10 mm. long, with truncate apex and smooth putamen.

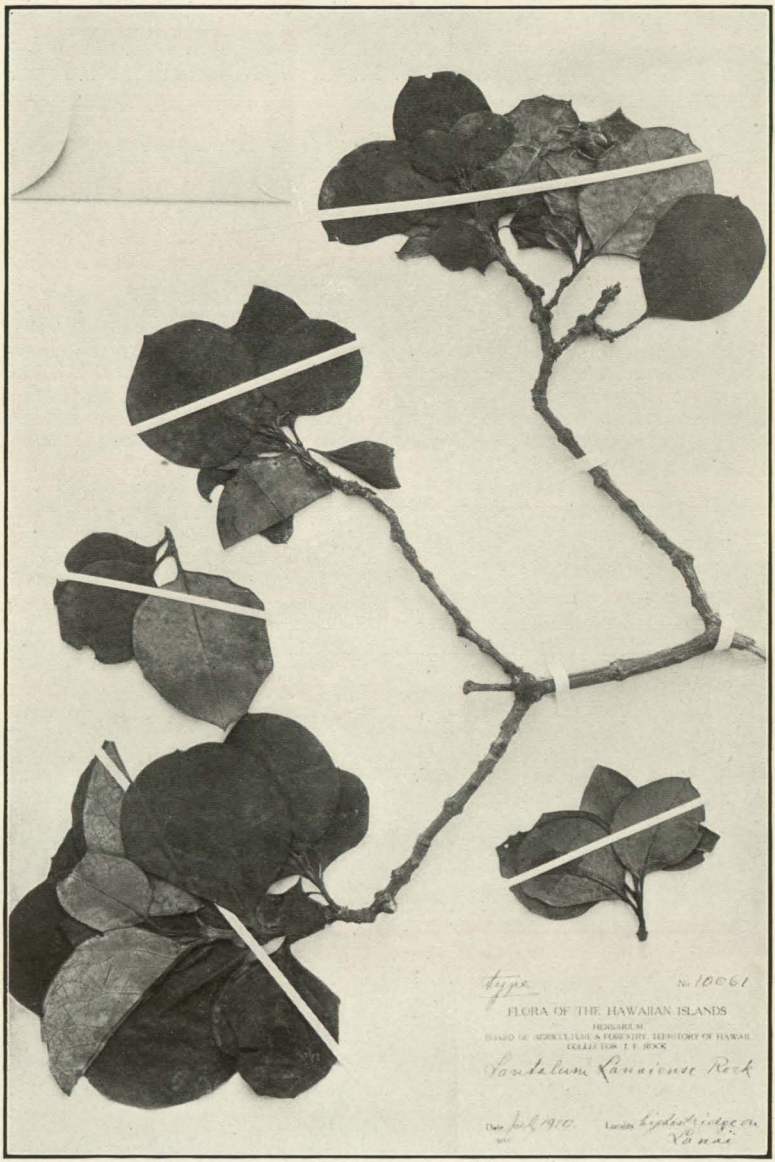
Oahu, eastern division, Palolo Valley.
Wahou (Oahu) Gaudichaud 1827, Ins. Sandwic., in Herbarium, Berlin.
Wouhala Oahu, Sandwich Islands, G. Bennett, December, 1830, in Herbarium, Berlin.
Oahu, Palolo Valley, Rock No. 10063, flowering, March, 1910, and No. 12512 flowering, September, 1912; in Herbarium, College of Hawaii.

This is the typical *Santalum Freycinetianum* Gaud. It occurs on the Island of Oahu on the eastern division and is quite common in Palolo Valley at an elevation of 600-1,500 feet; at the lower levels it is associated with *Acacia Koa* which is probably its host. At the higher level it grows in company with *Straussia kaduana, Elaeocarpus bifidus, Wikstroemia* and others.

This plant was confused by several writers, including the present one, with *S. ellipticum* Gaud.

In the Herbarium at Berlin (Royal Botanical Museum) there are two sheets of this species, one collected by Gaudichaud in 1827 part of the type, labeled *Santalum Freycinetianum* Gaud. It is identical with the plants from Palolo Valley. The second sheet is a specimen collected by G. Bennett* on Oahu in December, 1830, and bears the following label: "Santalum, Sandalwood

* Dr. George Bennett of Sydney, a veteran explorer.



Santalum Lanaiense Rock, type specimen.

Tree, Native name Iliahi or Lauhala.* Wouhala, Oahu, Sandwich Islands, December, 1830. The tree is of slow growth and inhabits elevated and rocky situations. G. Bennett." Bennett's plant is identical with Gaudichaud's specimen of *S. Freycinetianum.*

There are two distinct Santala occurring on the Island of Hawaii which were always referred to *Santalum Freycinetianum* Gaud., but are entirely different plants.

The plate in the Atlas of Gaud. Bot. Voy. Uranie does not quite coincide with the specimen collected by Gaudichaud which is the type, and of which a portion (ex. herb. Mus. Paris) is deposited in the Berlin Herbarium. The plates in general, issued under the above cited title, are quite inferior to those published by Gaudichaud in the Atlas of Bot. Voyage Bonite.

Santalum Lanaiense Rock

Santalum Freycinetianum Gaud. var. *Lanaiense* Rock, Indig. Trees Haw. Isl. 129, 1913.

A small gnarled tree, with stiff robust branches; leaves large orbicular in outline, 7-10 cm. each way, dark green above, dull on both sides, bright glaucous underneath, with red veins, chartaceous, mucronate at the apex, rounded or contracting at the base into a petiole of 5 mm.; inflorescence very small 2.5 cm., flowers in pairs or single on minute pedicels, large, bright red, with a glaucous hue, perigone 12 mm. long, campanulate to cylindrical, the acute lobes a third the length of the tube; disk with obtuse lobes of 1 mm.; filaments as long as the anthers, the tufts of hair nearly the length of the stamens; style 8 mm. long; slender, the stigmatic lobes short and blunt; drupe unknown.

Lanai: Highest ridge, Haalelepakai, elevation 3,000 feet, flowering July, 1910, Rock, type No. 10061 in the College of Hawaii Herbarium.

A remarkable tree, with the largest leaves of any Hawaiian Santalum; it belongs to the group with *S. Haleakalae* and *S. pyrularium,* the flowers are large, broadly campanulate and bright red.

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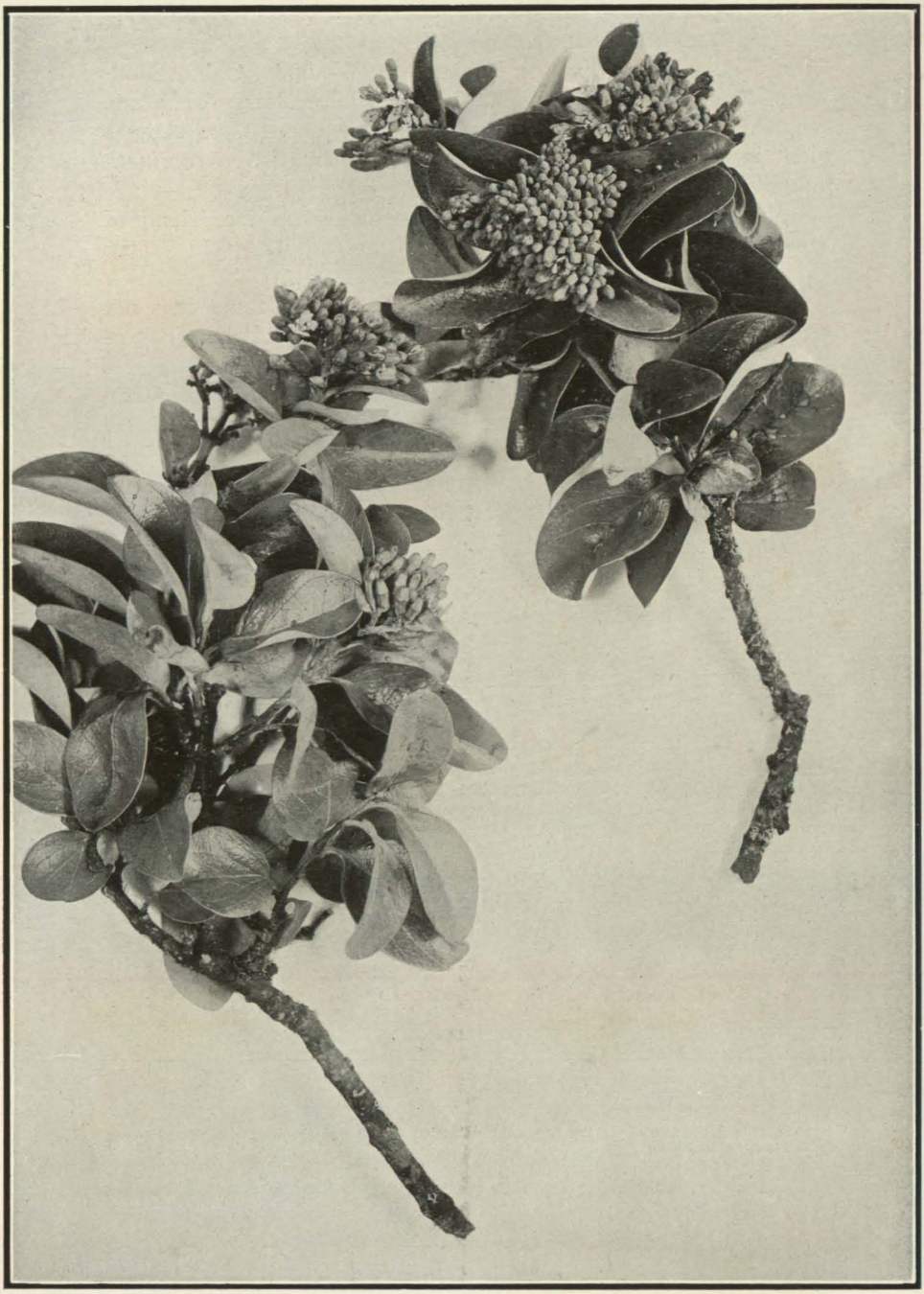
*Probably **Laauala**—fragrant wood, instead of **Lauhala** which is the native name for **Pandanus tectorius.**



Santalum Haleakalae Hbd.

Santalum Haleakalae Hbd. Fl. Haw. Isl. 390, 1888.
Santalum pyrularium Gray var. β Gray in mss. U. S. E. E.

A tree 3.5 m.—4.5 m. high with stiff gnarled branches at high elevation, longer slender branches at lower elevation; bark gray, corrugated; leaves coriaceous (chartaceous at lower elevations), ovate to obovate-oblong- or elliptical, dull green, with reddish midrib and veins, 3-5 cm. long, 2.5-3 broad, acute or rounded at both ends, on petioles of 3-6 mm.; inflorescence terminal, constituting a dense corymb of 8-10 cm. in length and as broad, flowers subsessile, deep carmine red, the perigonal tube 8-10 mm., the acute lobes nearly as long, disk lobes lanceolate longer than the filaments, the latter shorter than the anthers, the tufts of hair as long as the stamens; style exserted, 1 cm. long, 3—cleft, the lobes 0.5 mm.; drupe ovoid, 12x9 mm., purplish-black; with a blunt conical vertex.

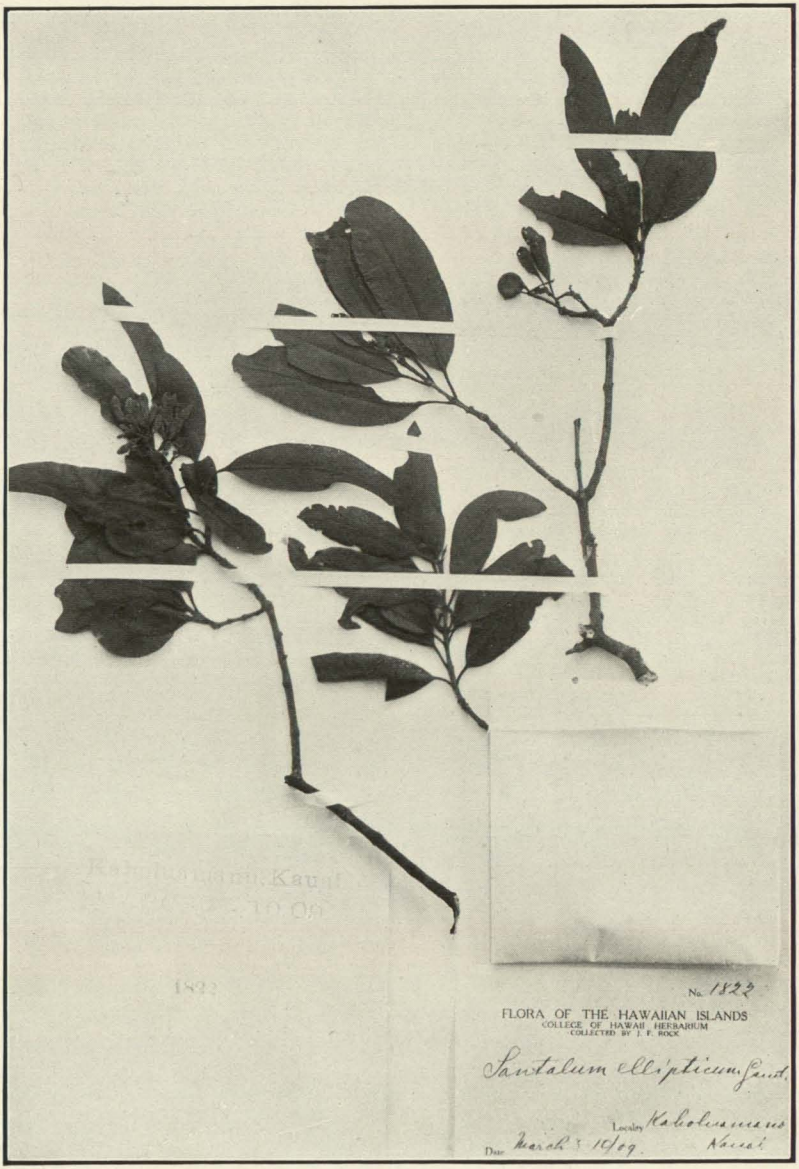
Maui: Haleakala, Hillebrand, July, 1858; in Herbarium Berlin;—Mann & Brigham No. 396;—Northeastern slope of Mt. Haleakala, Puunianiau Crater, elevation 7,000-9,000 feet, flowering and fruiting, Rock No. 8588 in College of Hawaii Herbarium. Southern slopes of Mt. Haleakala, lava fields of Auahi, Kahikinui elevation 3,000 feet, flowering, November, 1910, Rock No. 8659 in the College of Hawaii Herbarium.

In the Berlin Herbarium are three sheets, two collected by Hillebrand without number, in July, 1858, on Haleakala, and are labeled *Santalum paniculatum* H. et A., both however are typical *S. Haleakalae* Hbd.

The third sheet also labeled *S. paniculatum,* comes from Kauai, leg. Knudsen No. 171, but is hardly referable to this species.

S. Haleakalae comes indeed very close to *S. pyrularium* and *S. ellipticum* and may be in fact an intermediate between these two species. The writer's No. 8659 comes from a much lower elevation, and it is this plant which comes especially close to the Kauai species. The leaves are chartaceous and much larger, the inflorescence is, however, different and of a bright carmine red.

It has nothing in common with *S. paniculatum,* which has a small obconical perigonal tube.



Santalum ellipticum Gaud.

Santalum ellipticum Gaud. Bot. Voy. Uranie, 442, 1830.

Santalum Freycinetianum Gaud. var. ε *ellipticum* Gray in Mann Enum. Haw. Pl. Proc. Am. Acad. 7:198, 1868.

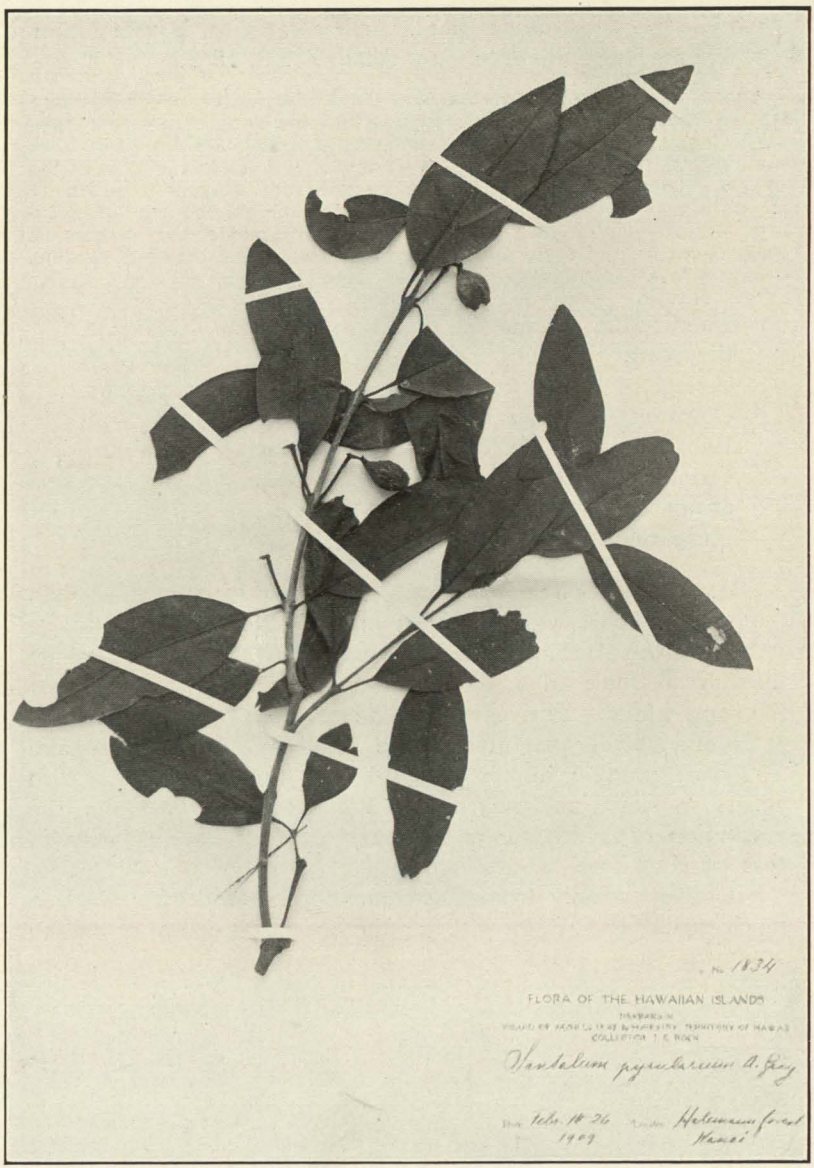
A smaller tree than **S. pyrularium**, trunk shorter, branches slender; leaves chartaceous to subcoriaceous, elliptical-oblong, acute or obtuse at the apex, dull green on both surfaces, glabrous 6-10 cm. long, 15-25 mm. wide, on slender petioles of 10-12 mm.; panicles in the axils of the upper leaves; pedicels 2 mm.; perigonal tube shorter than in **S. pyrularium**, 6-10 mm., the somewhat acute, oblong, reddish lobes 5-6 mm., diskus-lobes slightly shorter than the filaments, the anthers as long as the latter; style as in **S. pyrularium**; drupe smaller, 14 mm., ovoid, with a conical vertex, putamen slightly rough.

Kauai: Hbd. (Knudsen)?;—Halemanu near Puukapele, flowering February 14-26, 1909, Rock, No. 1816 in College of Hawaii Herbarium; forests of Kaholuamano, elevation 3,500 feet, flowering and fruiting March 3-10, 1909, Rock, No. 1822 in College of Hawaii Herbarium Oahu: western range Mt. Kaala, Hillebrand, in Herbarium Berlin without number, and College of Hawaii Herbarium, ex. Mus. Bot., Berlin.

Gaudichaud's plant is without number or locality other than Sandwich Islands. His specimen probably came from Oahu.

The Oahu specimens of this species from the Kaala range differ from those of *S. Freycinetianum* from Palolo Valley of the same island. The leaves remind of those of *S. pyrularium*. It is undoubtedly an intermediate between *S. pyrularium* and *S. Freycinetianum*, and is more allied to the former, as it also occurs on Kauai and only on the Waianae range on Oahu, the vegetation of which range is remarkable for its similarity to that of Kauai.

It differs mainly from *S. pyrularium* in the drupe, which is much smaller in *S. ellipticum*, and the less rough or rather smooth putamen.



Santalum pyrularium Gray. Fruiting specimen.

Santalum pyrularium Gray Proc. Am. Acad. 327, 4: 1860.

A tree 10-15 m. high, with slender, more or less ascending branches, glabrous throughout; leaves dull green, with reddish veins and petioles, somewhat glaucous underneath, elliptical-oblong, acute or acuminate at the apex, 7-10 cm. long, 3-4 cm. wide, subcoriaceous, acute at the base, on petioles of 1-1.5 cm.; panicles axillary about 2.5 cm., loosely few-flowered, pedicles about 3 mm.; perigone dull red, cylindrical, 12-14 mm. long, the lobes 6-8 mm., disk lobes narrow, obtuse, nearly as long as the filaments, the anthers as long as the filaments; tufts of hair long; style slender, as long as the perigone (including the lobes), stigma three-cleft,; drupe large, obovoid, nearly 2 cm. long, with a small conical apex, the putamen rough, runcinate.

Kauai: U. S. E. Exped.;—Hillebrand, a fragmentary specimen in the Herbarium Berlin;—Gebiet um Halemanu, Wawra No. 2137, 2342 in Herbarium Vienna;—Halemanu, forest of Kopiwai and Halemanu proper, elevation 3,600 feet, flowering and fruiting, February 14-26, 1909, Rock, No. 1834 in the College of Hawaii Herbarium.

This very distinct species inhabits the outskirts of the forests as well as the semi-dry mixed forests of Kauai, especially Halemanu and Kaholuamano, where it grows in company with *Elaeocarpus bifidus, Tetraplasandra Waimeae, Pterotropia kauaiensis, Bobea Mannii, Straussia, Alphitonia excelsa* and others. When growing farther inland on the borders of the rain forests it develops a straighter trunk and is also taller.

It differs from the other related *Santala* in the long, oblong-elliptical leaves, large cylindrical perigone, but mainly in the large, obovate drupe, with the runcinate, rough putamen. *Santalum ellipticum* Gaud. may only be a variety of this species, and may be intermediate between this species and the typical *S. Freycinetianum* from Palolo Valley, Oahu.

The specimen in the Berlin Herbarium is only fragmentary.

Santalum pyrularium Gray. Flowering specimen.

Santalum Pilgeri Rock, n. sp.

Santalum Freycinetianum Hbd. (not Gaud.) in part, Fl. Haw. Isl. 389, 1888.

Santalum Freycinetianum Rock (not Gaud.) Indig Trees Haw. Isl. 127, 1913.

A tall tree 14-16 m. in height, with a straight trunk 3.4 dm. in diameter, bark black, smooth, branches straight, more or less ascending, leaves opposite, dark green, glossy, glabrous on both surfaces, with a strong, prominent midrib, ovate to obovate, obtuse or slightly pointed at the apex, 6-10 cm. long, 3-5 cm. wide, acute at the base, on a somewhat margined petiole of 4-6 mm.; the foliate branchlet slightly flattened with prominent lateral ridges, or almost alate; racemes short, axillary in the upper leaves, 1.5-3.5 cm. long, flowers sessile or subsessile in clusters of 3-6 or more; perigone orange-yellow, the tube exceedingly short, obconical, 3 mm. high, the broad acute lobes 2 mm.; lobes of disk broad, sinuses broad and deep, tufts of hair rather short, anthers longer than the filaments, hiding the latter; style reaching to half the length of the tepala, minutely three-cleft; drupe ovoid, smooth, black, truncate at the apex.

Hawaii: Kona, Hillebrand, 1862, in Herbarium, Berlin, and College of Hawaii Herbarium.
South Kona, Pulehua on *aa* (rough) lava flows above Kealakekua, elevation 5,000 feet, bordering the great central plain, Rock, flowering and fruiting Feb. 10, 1912, type No. 10033 in the College of Hawaii Herbarium.

This remarkable species which was confused with *S. Freycinetianum* is very distinct and differs from it in its habit, the short obconical perigone, the large, stiff, dark green leaves, and short axillary inflorescence, as well as large, ovoid drupe, with the projecting limb of the perigone.

It is a large tree reaching a height of 40-50 feet and even more and forms quite a little forest of its own on an *aa* (rough) lava field near Pulehua, on the southern slopes of Mauna Loa, at an elevation of 5,000 feet. It is remarkable for its tall, straight trunk, of often nearly 2 feet in diameter, and the black, perfectly smooth bark.

In the Herbarium of the Royal Botanical Museum at Berlin, there is one sheet collected by Hillebrand and labeled *Santalum Freycinetianum* var. *Gaudichaudii*, Kona, Hawaii, 1862. Prof. Pilger who had revised the Santalaceae preliminarily, recognized it as a distinct species and marked it *Santalum affine* n. sp. Pilger. The plant is here named for Prof. Pilger. The specimen in the Berlin Herbarium is identical with the writer's plants from Pulehua, Kona, Hawaii.

Plate VIII.

Santalum Pilgeri Rock Type.

Santalum Pilgeri var. **luteum** Rock, n. v.

A medium sized tree 10-15 m. high, with a straight trunk 3 dm. or more in diameter, bark dark gray, deeply corrugated, several centimeters thick, branches stiff; leaves thin, chartaceous, ovate-oblong to elliptical, acute at both ends, 6-8 cm. long, 2.5-3.5 cm. wide, glossy shining above, yellowish-green and dull underneath, on petioles of 1 cm.; inflorescence paniculate, and axillary, the rhachis short 1-1.5 cm., pubescent throughout, perigone smaller than in the species, the obconical tube less broad, 2.5 mm., otherwise as in the species; drupe ovate, the size of a ripe olive, 14 mm. long and 9 mm. thick, purplish-black, with an acute conical vertex, putamen smooth.

Hawaii: On the lava flows of South and North Kona; Huehue to Puuwaawaa, North Kona, slopes of Mt. Hualalai, elevation 2,000-3,000 feet, flowering June, 1909, Rock, type No. 3728 in the College of Hawaii Herbarium;— Kapua, South Kona, flowering January, 1912, Rock No. 12515 in the College of Hawaii Herbarium.

This variety is not uncommon on the lava flows between Huehue and Puuwaawaa, along the government road where it is a small tree, while on the slopes of Mt. Hualalai, a thousand feet higher, it is a big tree, 40-45 feet in height. It differs from the species in the gray, deeply corrugated bark, yellowish, ovate-elliptical, thin leaves, and the olive shaped drupe which is crowned with an acute, conical vertex. The trees from Kapua, South Kona, are much smaller than those from Puuwaawaa.

Plate IX.

Santalum Pilgeri var. **luteum** Rock. Flowering and fruiting specimens, type.

Santalum paniculatum Hook et Arn. Bot. Beech. Voy. 94, 1832.

Santalum Freycinetianum Gaud. var. *latifolium* A. Gray Proc. Am. Acad. 327, 4: 1860.

A much branching shrub or small tree 4-6 m. high; leaves chartaceous to subcoriaceous, pubescent when young ovate to obovate, bright green above, glaucous underneath, rounded at the apex, contracting at the base into a very short, slightly margined petiole of 4 mm.; inflorescence paniculate, large, terminal, or in the axils of the upper leaves, covered with an olivaceous-grayish pubescence, panicles densely flowered, 5-10 cm. long; the subsessile perigone glaucous, slightly pubescent, the tube obconical 3 mm., the broad acute lobes 2 mm.; disk with broad shallow sinuses, the lobes short, rounded; anthers slightly longer than the filaments; tufts of hair the length of the stamen; style reaching to half the length of the tepala; the 3 minute stigmatic lobes capitellate.

Hawaii: U. S. E. Exped.;—Hualalai, Central plateau, Kilauea, Hbd. Nos. 400, 422, 490 in Herbarium of Berlin;—Kilauea Volcano, along trail, flowering Aug., 1911, Rock, No. 8770 in the College of Hawaii Herbarium;—Central Plateau, Puuoikaaka Crater, slopes of Mt. Hualalai, elevation 5,700 feet, flowering Feb. 13, 1912, Rock, No. 10048 in the College of Hawaii Herbarium;—Near Kilauea, in Shipman's paddock, growing in company with *Metrosideros polymorpha* and *Acacia Koa*, flowering and fruiting (immature) Oct. 30, 1915, W. M. Giffard, No. 12517 in the College of Hawaii Herbarium.

Maui: West Maui, Lydgate No. 157, in Herbarium, Berlin.

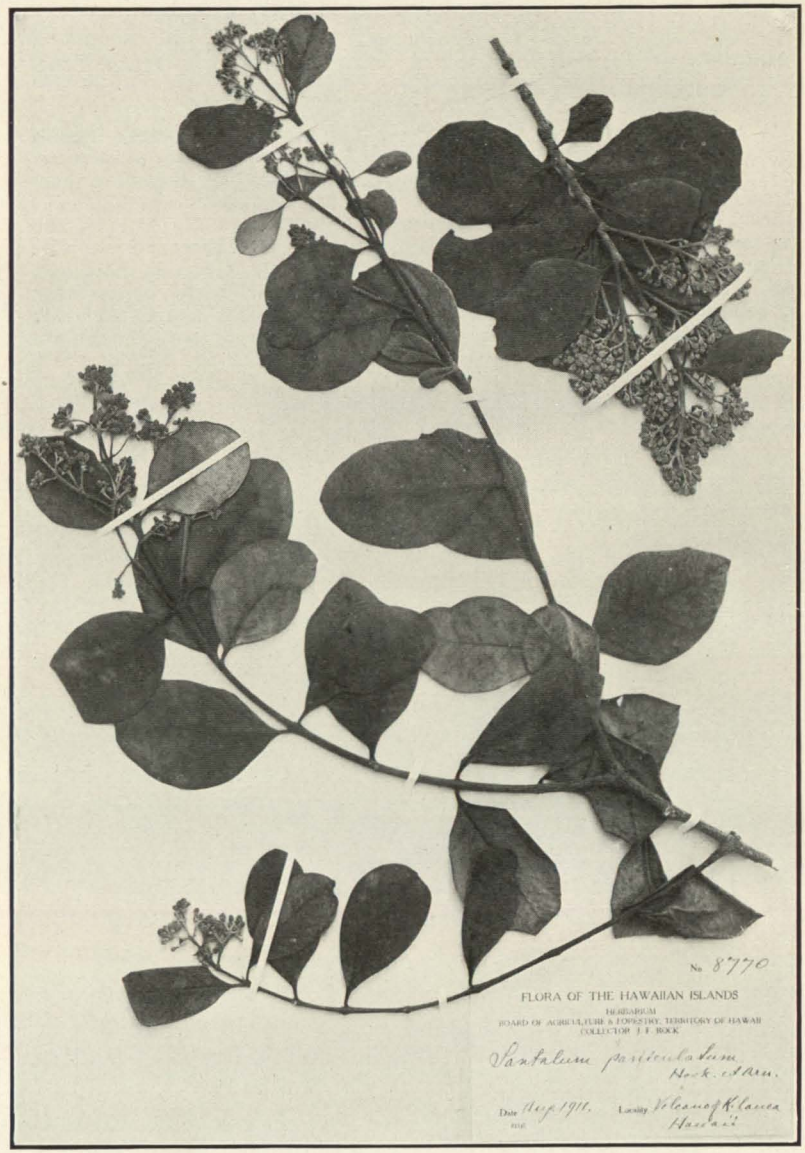
Molokai: Halawa, Hbd. in Herbarium, Berlin.

Lanai: Lydgate No. 156. Labeled, "*Santalum Freycinetianum* var. *obovatum*, small tree"; in Herbarium, Berlin.

Kahoolawe: Remy No. 507, specimen not seen by the writer.

The typical form of this species occurs on the Island of Hawaii, along the trail leading to the Volcano of Kilauea and in the immediate neighborhood of the Volcano House, along, and in large steam cracks. It is distinct from *S. Freycinetianum* Gaud. and differs from it in the large densely flowered, glaucous, panicle, the obconical tube of the perigone, which is as a whole much smaller; also in its habit of growth, being a shrub

Plate X.

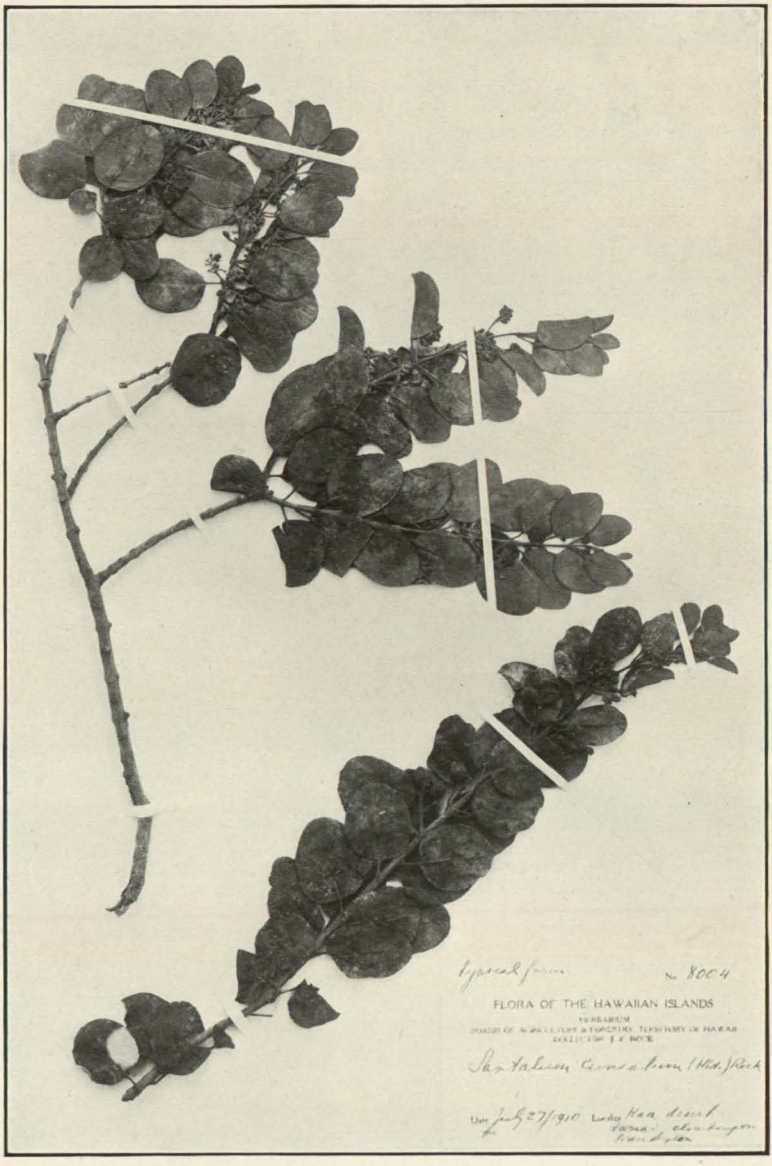


Santalum paniculatum Hook. et Arn. Flowering specimen.

12 feet in height, and its large ovate to obovate glaucous foliage The numbers 400, 422, 490 (ex. Herb. Hillebrand) in the Berlin Herbarium are identical with the specimen of *Santalum paniculatum* H. et A. in the Kew Herbarium.

No. 12517 collected by W. M. Giffard is a small tree and is quite common near the Shipman ranch house as well as on the outskirts of the *aa* (rough) lava flows encircling the Kipuka Puaulu, also found beyond, along the trail to Kipuka Ki, elevation 4,000 feet. It is also not uncommon along the trail to Puuhuluhulu and Makaopuhi crater. It differs from the plants found in the fissures near the Volcano House, mainly in the smaller leaves which are ovate-elliptical, and in its habit, it being a small tree 15-25 feet in height.

Plate XI.



Santalum cuneatum (Hbd.) Rock. Typical form from Lanai.

Santalum cuneatum (Hbd.) Rock

Santalum Freycinetianum Gaud. var. γ *cuneatum* Hbd. Fl. Haw. Isl. 389, 1888.

A shrub with long rambling or even climbing branches, leaves thick, coriaceous, orbicular to suborbicular, slightly emarginate at the apex, base cuneate to truncate, 2-3 cm. in diameter, on petioles of 5-10 mm.; inflorescence in the axils of the leaves all along the branchlets; flowers slightly pedicellate, perigone glaucous, the tube obconical, 2-3 mm., the acute, spreading lobes 2 mm., yellowish; disk and stamens as in **S. littorale**, the style longer than the perigonal tube; drupe subglobose, 8 mm. in diameter, with a truncate apex, and the remnant of the style.

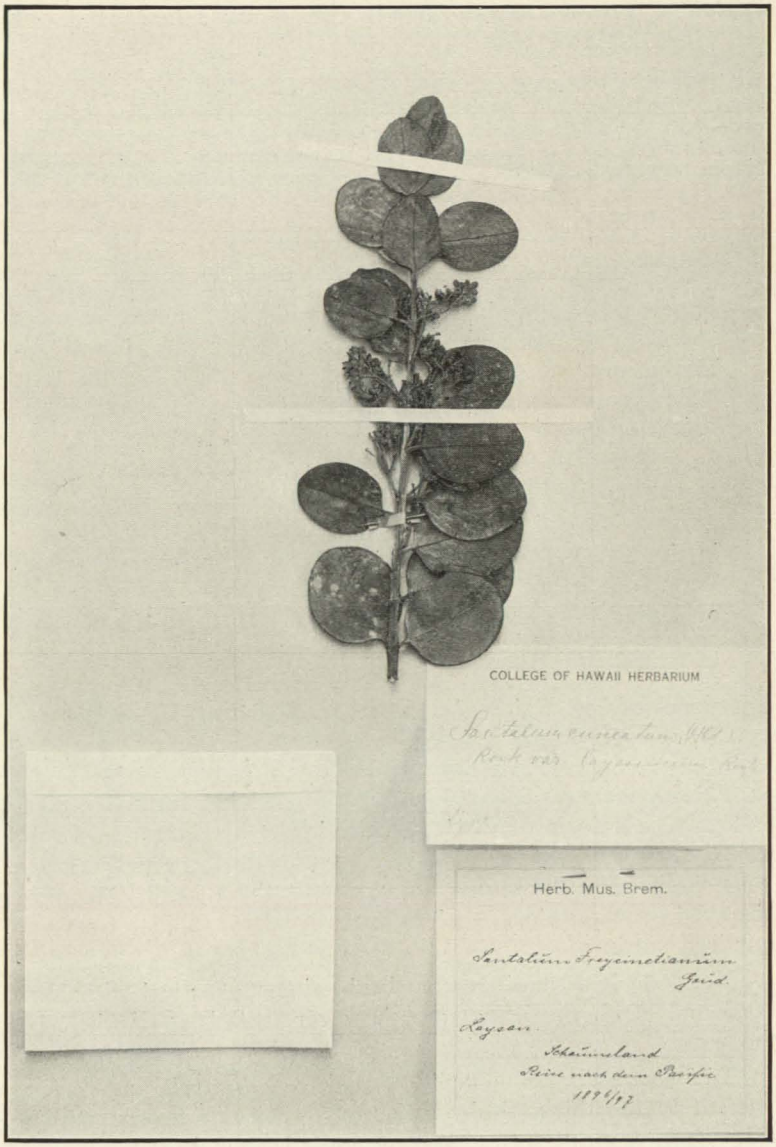
Lanai: Hillebrand, July, 1870, without number, one sheet in Herbarium, Berlin, and College of Hawaii Herbarium, ex Mus. Bot. Berlin.
Kaa Desert, western end of Lanai, elevation 2,000 feet, flowering and fruiting, found climbing on a Sideroxylon, July 27, 1910. Rock, No. 8004 in the College of Hawaii Herbarium;—Eastern end of Lanai on open, exposed, grassy places, flowering, July 29, 1910, Rock, No. 8013 in the College of Hawaii Herbarium;—Central part of Lanai, back of Koele on dry rocky slopes, on verge of Mahana Valley, flowering July 27, 1910, Rock, No. 8048 in the College of Hawaii Herbarium.
Maui: on lava fields of Auahi, Kahikinui, southern slopes of Mt. Haleakala, elevation 2,700 feet, flowering Nov., 1910, Rock, No. 8683.

The numbers 8013 and 8048 differ somewhat from No. 8004 and may be a form of the latter, the leaves are larger, ovate to suborbicular, the base is not quite truncate and the petioles are longer, otherwise the same. Of No. 8013, three small trees were observed growing alone, with no trees within a radius of several hundred yards.

No. 8683 is a small tree or shrub, almost identical with Nos. 8013 and 8048, the leaves are, however, still larger, otherwise the same.

This species is undoubtedly related to *S. littorale*, but differs from it in the thick, fleshy-coriaceous, orbicular leaves, with a truncate to cuneate base. It is a much larger shrub with long rambling, scandent branches, often climbing on other trees. Type in the Herbarium, Berlin, ex herb. Hillebrand.

Plate XII.



Santalum cuneatum (Hbd.) Rock var. **laysanicum** Rock; type.

Santalum cuneatum var. **laysanicum** Rock n. v.

Santalum Freycinetianum Bitter (non Gaud.) Abh. Nat. Ver. Bremen XVI: 3, 433, 1900.

A shrub 2.5 m., or higher, main stem 10 cm. in diameter, glaucous throughout; leaves orbicular-suborbicular, to ovate, thick-coriaceous to fleshy, 3.5-4.5 cm. both ways, rounded, or slightly acute at the apex (only in ovate leaves), truncate at the base, on petioles of 2.5 mm. or subsessile; panicles 2.5 cm., flowers sessile or subpedicellate; perigonal tube obconical, glaucous, 2 mm., the broadly-ovate, acute lobes 3 mm.; disk-lobes as long as the filaments, tufts of hair short, anthers ovate, shorter than the filaments; style exserted, 3-cleft, drupe obovate, 12 mm., black, ribbed (when dry), apex truncate.

Laysan Island: An der Uferzone der Insel, am üppigsten an der Nordwestseite, flowering 1896-1897, Prof. Schauinsland, No. 20, in Herbarium Museum Bremen, and in the College of Hawaii Herbarium;—Wm. A. Bryan, without number, flowering specimen in the College of Hawaii Herbarium;—D. T. Fullaway, flowering and fruiting Dec., 1912, in the College of Hawaii Herbarium.

This variety differs slightly from the species, but mainly in the larger leaves, and larger, obovate, ribbed drupe, otherwise as in the species, with the exception of stature which in the variety is a short stiff shrub, with stout branches and branchlets.

It grows near the beach, especially gregarious on the northwest side of the Island (teste Schauinsland), and is the largest plant on the Island.

Plate XIII.

Santalum littorale (Hbd.) Rock. Typical specimen from Diamond Head, Oahu.

Santalum littorale (Hbd.) Rock

Santalum Freycinctianum ϵ var. *littorale* Hbd. Fl. Haw. Isl. 390, 1888.

A low and stiff shrub 1-1.5 m. in height, with grayish gnarled branches, leaves glaucous or dull pale, small, 2.5-3.5 cm. long, 1.5-2 cm. wide, ovate to elliptical, coriaceous, with thickened margins, acute or somewhat obtuse, the veins not very prominent, on slender petioles of 5-10 mm.; flowers terminal and axillary, glaucous, fragrant, sessile or slightly pedicellate, brick red to yellowish; the perigonal tube not broadly obconical, 4 mm., the acute lobes 2 mm.; diskus lobes short, rounded, stamens little longer than the filaments, 1 mm.; style slightly protruding beyond the tube, the 3 minute stigmatic lobes capitellate; drupe globose, glaucous when young, 6-7 mm. in diameter.

Oahu: Kape Kaena, Waianae, seashore, and Kailua, Hbd. 1869, in Herbarium Berlin.
Diamond Head, near the government road and on slopes below the road, near sea, flowering 1910, Rock, No. 12513, in the College of Hawaii Herbarium.
Koko Head, flowering, G. W. Shaw, No. 12514 in the College of Hawaii Herbarium.
Hawaii: Shores Kealakekua, observed flowering February, 1912, Rock.

This interesting Santalum is worthy of specific rank; it cannot be retained as a variety of *S. Freycinetianum* Gaud. since it is more related to *S. Pilgeri* Rock, having an obconical perigonal tube instead of a campanulate-cylindrical one.

It belongs to the groups of *S. paniculatum, S. cuneatum,* and *S. Pilgeri,* all with an obconical perigonal tube, while *S. pyrularium, S. Freycinetianum, S. ellipticum* and *S. Haleakalae* possess more or less cylindrical perigonal tubes.

The type of this species is in the Berlin Herbarium (ex. herb. Hillebrand) without number.

ADDENDUM.

Through the courtesies of Miss Mary A. Day, Librarian of the Gray Herbarium, the writer has come into the possession of an article on the Genus Santalum by M. G. Meurisse entitled *"Etude du genre Santalum L."* published in *"Bulletin Mensuel de la Societe Linneenne de Paris,"* 1892.

In his article Meurisse describes a new species of Santalum, *S. longifolium,* based on a specimen collected by J. Remy on Oahu, and raised a variety *latifolium* of *S. Freycinetianum* to specific rank; his *S. latifolium* was, however, already described by Hooker et Arnott as a distinct species under the name *Santalum paniculatum*; the writer is unable to see why the much earlier specific name *paniculatum* should have been discarded for the newer name of Gray *latifolium.* His *Santalum longifolium* from Oahu is probably the narrow leaved form of the typical *S. Freycinetianum* from Oahu.

He also mentions of having described two varieties of *S. Freycinetianum* var. *vulgare* and *multinerve* but fails to mention if they came from the Hawaiian Islands or from one of the South Sea Islands, as *S. Freycinetianum* is supposed to occur in Tahiti from which place it was described under the name of *S. insulare* by Bertero. Meurisse states in conclusion that the complete description of the other species (none Hawaiian) and varieties may be found in *Bulletin des Sciences naturelles,* numbers March and April, 1892.

The writer has in vain tried to secure the loan of the above mentioned numbers from various libraries in the States; the publication mentioned being not available and seeming not to exist in America.

In fact one librarian states that she doubts if the articles were even published as no reference could be found anywhere, other than Meurisse's own of May, 1892.

The reference in Index Kewensis, Supplement One, page 379, regarding *S. longifolium* is wrong. In Index Kewensis it is given as coming from New Zealand, while Meurisse states Hawaiian Islands, Oahu. *S. Salicifolium* Meurisse is given in Index Kewensis as coming from Hawaii, while Meurisse states it to have been a variety of *S. Cunninghamii* from New Zealand.

Appended is the description of *Santalum longifolium* Meurisse, Bull. Soc. Linn. Paris, 1026-1027, 1892.

Feuilles très longues et très larges, ovales-aigues, longue-

ment atténuées à leurs deux extrémités, d'un vert sombre et lisses en dessus, plus pâles et ternes en dessous, à nervure principale surtout saillante inférieurement, à nervures secondaires nées à angle tres aigue, aussi visibles à la face supérieure qu'à la face inférieure, et devenant toutes parallèles aux bords du limbe qu'elles suivent jusqu'à son commet. Pétiole très long (le plus long de toutes les espèces vues jusqu'ici). Cymes composées, axillaires ou terminales, plus courtes que les feuilles. Fleurs courtement pédicellées, à périanthe profond, à lobes plus courts que le tube. Etamines à anthères égales à leurs filaments, ècartèes en X á la maturité et terminées supérieurement par deux petites cornes hyalines. Quatre faisceaux de poils longs en arrière de cellsci. Lobes du disque arrondis, aplatis. Style ordinairement plus long que le sommet des anthères—deux our trois stigmates, ovaire presque complètement infère, à placenta peu allongé, 2-ou 3-ovulé. (Limbe: long., 10 centimètres; larg., 3 centimètres et demi. Pétiole: 2 à 2 centimètres et demi. Fleur: long., 12 millimètres (av. pédicelle 2 millimètres et demi), larg., 4 millimètres.)